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PLATE 3.—Parts of apetalous summer flowers, and (fig. 4) hairs of lateral petals of spring flowers of *Viola candidula.*

FIG. 1a.—Pistil of apetalous flower with stamens appressed to the stigma. (Side view.) A minute sterile stamen on the left between the two fertile ones.

FIG. 1b.—A fertile stamen with four anther sacs. Pollen escaping from the subapical cleft in the two larger sacs. Rudiment of another sterile stamen at the base. [Magnified about 30 diameters].

FIG. 2a.—Cross section showing arrangement of the parts of the apetalous summer flowers. A, position of the recurved petiole. B, sepals, subequal. C, 2 stamens bearing fertile anthers and inserted always next to the petiole A. (The third sterile stamen is ordinarily absent.) D, ovary with ovules.

FIG. 2b.—Front view of pistil with two stamens. (Same as Fig. 1a of another flower without the third sterile stamen.)

FIG. 3.—Side view of recurved style and stigma showing pollen grains sending pollen tubes into the hollow style.

FIG. 4.—Hairs of the beard of the lateral petals greatly magnified. The hairs are spirally striate under high magnification and round, not flattened except in age.

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Some Littoral Algae of Puget Sound.

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The following study was made at the Puget Sound Marine Station, during the summer of 1909, mainly in the months of July and August. A general survey of the ground had been made the previous summer. Its purpose was to determine what types of algae inhabit the tide-pools; why they prefer these places and how they are specially adapted to such places. The study was made with special reference to *Prionitis*, which seems to be the one prevailing type in all these tide-pools, and showing considerable variation with variety of environment.

The work was suggested and outlined by Professor T. C. Frye, acting director of the Station. No such study had yet been made in this region, though a study somewhat similar in its general character was made by Skinner (8) at Port Renfrew, B. C. The conditions there are quite different, and his study does not attempt to relate types to environment, nor is it specially directed to any particular form. In the 1906 Postelsia there is a report by Isabel Henkel (3) on the tide-pools near Port Renfrew, B. C. from the standpoint of their origin. It is mostly geological in character and only incidentally refers to the algae there found. In that place the tide-pools are of unusual character, large and deep, mostly in sand-stone. In my study the term tide-pool includes anything from a few pints to many gallons, left by the receding tide or splashed by the spray above tide-mark.

The plants were identified by comparison with the collection at the Station and are named according to Setchell and Gardiner's "Algae of North-western America," except Nos. 1 and 2, which were identified and named by comparison with the private collection of A. S. Foster of Aberdeen, Wash. and with the collection at the University of Ill. in which these were named by Professor Tilden of the University of Minnesota. No. 3, also, is the name given by Professor Tilden to a specimen from the north end of San Juan Island, closely resembling, if not identical with those classed by me under that name. There was some doubt as to whether all the *Prionitis* should be classed as variations of one species or as distinct species. Setchell, (5) discusses the same question in regard to *Ulva*, holding that it is merely one species, with much variation due to differences of environment.

The list of places named does not pretend to cover the entire Sound region but it is fairly typical and sufficiently exhaustive. There are no pools at the south end of the Sound, where the shores are mostly of clay or gravel. They are best represented about the island regions and are most typical where these studies were made. In an Ecological study by Wylie (9) of a small rocky island off the south end of Lopez Island *P. Lyallii* is reported further south than any point studied by me. Many regions were studied or noted that are not included in this report. Only those were included which were considered most typical. They were mostly made at extreme low tide in order to make comparisons possible. They are numbered in the order in which they were studied.

I. Brown's Island, chiefly west side and south end.

1. *Melobesia marginata*, forming reddish-brown incrustations on rocks at the high-tide line and in shallow pools.

2. *Peyssonnellia dubia*, rather thick incrustations in crevices

or other protected places, from mid-tide to lowest visible depths; sometimes on loose rocks or shells.

3. *Prionitis lanceolata*, in tufts on the margin of the pools.

4. *Prionitis Lyallii*, coarser, less divided and lighter colored than No. 3 and characteristic of mid-tide or deeper.

5. *Polysiphonia californica*, growing in fine masses in the deeper water; sometimes in shallow water or on loose rocks.

6. *Rhodomela larix*, growing in large course masses in deeper water, and most abundant at low tide.

II. Shaw's Island, south end; pools larger, greater variety in size, elevation and light relation.

No. 1, almost wholly absent in this region; cause unknown.

No. 2, good display at lower depths in protected crevices.

No. 3, abundant at mid-tide, showing marked contrasts in size of plants and profusion of branching.

No. 4, large size, mid fronds nearly a foot long; branching, less profuse, lateral; color, yellowish.

No. 5, a small amount at low tide.

III. Minnesota Reef, a rock about two miles south-east of I. totally submerged at extreme high tide (spring-tide) and hence was visited at the ebb of spring-tide. It is very rich in amount and variety of material, but is not strictly tide-pool in character at all times.

No. 1, very rare and of little importance here.

No. 2, abundant; some on shells and loose rocks and it could be seen at inaccessible depths.

No. 3, present in considerable quantities, finely divided.

No. 4, as described in II, good specimens. This varied enough to suggest two or three species or varieties.

No. 5, in great masses; optimum conditions.

No. 6, as in I. almost below tide-pool conditions.

No. 7, *Ulva lactuca*, in medium abundance at low tide.

No. 8, *Gigartina mammilosa*, not abundant nor important.

Corallina and *Amphiroa* were also found here in considerable abundance, but scarcely in tide-pool conditions; hence they will receive no further consideration. These have been treated in a monograph by Yendo (10).

IV. Unnamed rock, ½ mile south of III. This gave the same indications as III. with greater variety in *Prionitis*, as it extends above high-tide, affording small pools filled by spray and always exposed to sun and air; consequently warmer than pools below the tide-line; sometimes reaching 70°F. At this and the previous place, III., temperatures were taken; they ranged from 53°F to 63°F. Thus, allowing 10 ft. between low and high (it is nearly 12 ft.) there is an average difference of 1° for each ft. of altitude.

V. Argyle Bay. This is really the outlet to a large pond or basin that is drained almost completely when tides are lowest. The flood comes in over an expanse of warm gravel and the pool is shallow so the water may reach at times a temperature of 60° to 70°F. At the outlet the water is constantly flowing either in or out with considerable current, thus renewing the air and food supplies.

Nos. 1 and 2 are not found here as the banks are loose gravel instead of solid rock; and the quiet water conditions of other places do not exist.

No. 4, however, is found attached to large pebbles on the bottom and attaining great size; fronds over a foot in length and over an inch in width.

No. 5, also in great abundance fastened to pebbles.

Nos. 6, 7 and 8, though present are rare and not important, but No. 9, *Entermorpha linza* finds this a most congenial place.

VI. Roche Harbor, Henry Island and Ship Island. These show nothing new and are of interest only in so far as they confirm the conclusions already reached in the study of *Prionitis* and its variations elsewhere.

VII. "Gull Rocks," just off west side of Waldron Island. Excellent pools, varying in size and altitude, but containing almost nothing of interest except *Prionitis*. The conditions as to altitude, temperature, etc., are similar to those described under IV.

VIII. Kanaka Bay, also known as False Bay, south end of San Juan Island, drains completely at extreme low tide, when study was made east side of entrance.

This afforded a number of small pools and one larger than any found elsewhere; especially good. Although there is a great variety of material in this region there was nothing new in tide-pool conditions, except 10, *Soranthera sp. Prionitis* shows a greater variety of size and form here than possibly in any other place examined. It is doubtful whether it could all be classed under the two species, 3 and 4. Possibly it should all be classed as one species with much variation due to difference of environment.

IX. Sucia Islands, south side.

This was excellent ground for this study. The rock is softer and larger pools have been worn in them. They are more exposed to the sweep and surge of the tide and surf and better test the character of *Priontis*. This region is a resumé of all the others with enough new features to settle some of the problems raised by them. In other places the plants were more protected, which seemed to account for the presence of *Prionitis* rather than the higher temperatures or better light exposures. Long troughs are cut in the sea-floor which retain sufficient water at lowtide to support large quantities of *Prionitis*, but none is found there, evidently because the waves and tide sweeping the full length of the troughs sweep out this seemingly fragile plant, which is not adapted to such a strenuous existence. Why it has not become so adapted is another question.

DISCUSSION.

Prionitis is probably the only alga found exclusively in tide-pools and not elsewhere. It is found outside of tide-pools, properly so called and at greater depths than these, but in tide-pool conditions, essentially, and hence real tide-pools. *Rhodomela* seems to prefer the pools and probably for the same reason as *Prionitis*. Although abundant and nearly always found associated with the former, it is also found in crevices and protected places, in essentially tide-pool conditions, but deeper than its associate. It seems to shun extreme light and higher temperatures, which are found at higher altitudes. I thought at first that the plant went deeper only to find a firmer anchorage and shunned loose rocks, but I afterwards found it on rock fragments and shells; but these must, however, be protected from rolling and abrasion.

Prionitis is also more abundant where *Rhodomela* or like plants are present to afford protection; whether as points of attachment for young plants or later against strong currents is not apparent. It is preeminently not a surge-plant. It must have a protected nook or hollow. It does not grow on a sloping ledge as does *Calpomenia;* nor on a sheer rock wall as does *Fucus;* nor on a surf-beaten shore as does *Postelsia*. It exudes no slime and can not endure exposure to the air as does *Fucus*. It must grow in a pool or some protected place where it may secure much flowing water, as at Argyle Bay, and frequent exposure to the air for a short time is advantageous. Exposure to light seems to be of secondary importance.

Its presence in tide-pools may be due, in part to the abundance of animal life there, such as small crabs, snails, etc., which would furnish abundant Co_2 and preserve the well-known balance of plant and animal life. According to this view, however, if true, *Prionitis* should be able to grow in the center of pools as well as on the margins; but there it is not found. Possibly the gases accumulate on the margin. This point was not investigated for want of apparatus. This would be interesting and perhaps a profitable point for future investigation.

It was suggested at the outset that the difference in dissection, greatest at the top or upper tide-line and above, might be an adaptation to higher temperatures which would diminish the amount of gas and hence call for more exposure surface, which could be accomplished by more minute dissection of the fronds. This, however, does not seem to be true. In fact the opposite tendency is shown by Theoderesco (7) who, using certain liverworts for his investigations, found that the fronds of the thallus became shortened and more dissected when the concentration of the CO2 was increased.

This question was later taken up by the writer (2) in a somewhat extensive study on freshwater algae in which it appears that the plant body becomes more compact when the CO2 accumulates and that the alga is much concerned with its oxygen relation as well as with that of CO2.

In this connection I would cite the luxuriant growth of *Ulva* and *Alaria* at Olga and at Cattle Point, in the quiet shallow bays where the water becomes quite warm, 64°F. or more. These, with their broad thin leaves, are not adapted to rough water nor even to a strong current, but to quiet shallow bays with a pebbly bottom.

The finer dissection of *Prionitis* at the higher altitudes seems to be an adaptation to meet the force of the surf and strong currents, while the broad, simple fronds of the deeper levels are adapted to more quiet waters, and are especially prominent at Argyle Bay, where there is no surf but only a strong uniformly flowing current which rapidly renews the supply of CO2 without the danger of dislodgement or tearing. It is worthy of note that the light exposure is as great here as elsewhere. Rigg (4) mentions the fact that certain kelps show a variation in thickness and other features of form, coordinate with different degrees of exposure to violence of waves. Whether the dark brown color of the topmost plants, as contrasted with the yellowish tinge of the lower ones could be a color adaptation was not considered.

Setchell (6) mentions this color variation in kelps with increase of depth but does not offer any explanation nor suggest any idea of adaptation. Blackman (1) however, agrees with Gaidukov in the notion that the yellow color found in deeper waters is a chromatic adaptation to the complementary color of the rays coming through the blue water.

The problem of *Prionitis*, then, seems not to be so much the procuring of greater light and a warmer temperature but the supply and exchange of gases. In the pools the plants could attach themselves to the bottom as well as to the margin; but air and presumably CO_2 are not available at the bottom. So it seems that the small plants must begin life and the adults continue to remain around the margins, where gases are available and to do this must adapt themselves to a life of exposure on the one hand by increased dissection of the fronds, increased toughness and darker color and diminished size while the opposite of these are suited to a sheltered life.

CONCLUSION.

1. *Prionitis* is adapted to a considerable range of temperature, but seems to prefer the warmer places.
2. *Rhodomela* is adapted to nearly as wide a range of temperature, but seems to prefer the cooler places.
3. Both seek protected nooks and pools.
4. The problem of *Prionitis* seems to be that of food (CO_2) and shelter rather than of heat and light.

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Notes on Our Local Plants.—IV.

BY J. A. NIEUWLAND.

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[1] Referred by Linnaeus to Gronovius here, and hence credited above to that author, even though first found used by the former.